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Ionic conductivity of novel solid polymer electrolyte based on polyethylene oxide (PEO) and magnesium pyrophosphate ($Mg_2P_2O_7$)

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Lithium-ion batteries were hailed as a breakthrough solution for energy storage, revolutionizing portable electronics, electric vehicles, and other applications. However, as their implementation expanded, certain drawbacks came to light. Issues such as limited energy density, safety concerns, and the scarcity and high cost of lithium resources highlighted the need for a replacement. Researchers turned their attention to alternative materials, with sodium being a promising candidate due to its abundance. However, its high reactivity posed significant challenges. The search for a viable alternative led scientists to explore magnesium-based electrolytes. Lithium and magnesium are almost similar in ionic radii, presenting an exciting opportunity for further research. In this Investigation, the focus was on synthesizing and characterizing a novel magnesium ion-based solid polymer electrolyte. Polyethene oxide (PEO) was chosen as the polymer host, and magnesium pyrophosphate ($Mg_2P_2O_7$) as the dopant salt. By varying the amount of salt while keeping the same amount of PEO, five different types of electrolytes were made: $PEO_5Mg_2P_2O_7$, $PEO_{10}Mg_2P_2O_7$, $PEO_{15}Mg_2P_2O_7$, $PEO_{20}Mg_2P_2O_7$, and $PEO_{25}Mg_2P_2O_7$. The hot-pressed technique was used to fabricate the solid polymer electrolytes, and the resulting materials were characterized in the frequency range of 1Hz to 1 MHz using the Gamry framework version 6.11. Arrhenius plots were derived from Nyquist plots to study the conductivity variation with temperature. The temperature range for the study spanned from 25°C to 100°C. The characterization results revealed that among the different electrolyte samples, $PEO_{10}Mg_2P_2O_7$ demonstrated the highest electrical conductivity of 5.0×10^{-6} Scm^{-1} at 50°C. This temperature was selected since the melting point of PEO is 64 °C. This value of conductivity is comparatively lower than most existing magnesium ion-based solid polymer electrolytes. The results from this study pave the way for further investigations and improvements. Incorporating fillers could enhance the conductivity of the electrolyte material and improve its overall performance. Such advancements may yield even more promising results, making magnesium-based solid polymer electrolytes viable candidates for solid-state batteries. Alternatively, a gel polymer might give a more promising result than a solid polymer.

Keywords: Arrhenius plot, Ionic conductivity, $Mg_2P_2O_7$, Nyquist plot, PEO